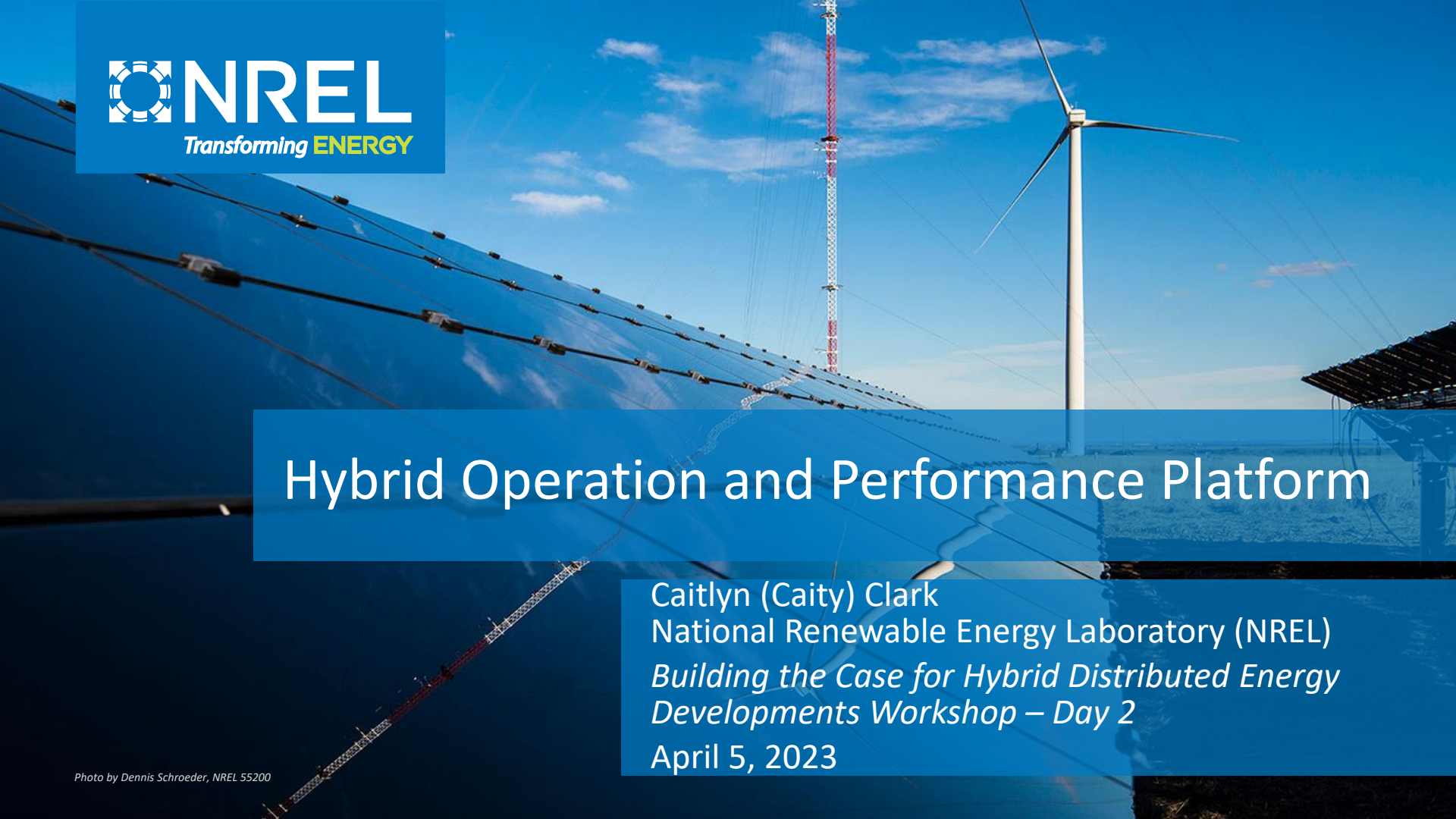

Hybrid Operation and Performance Platform

Caitlyn (Caity) Clark
National Renewable Energy Laboratory (NREL)

Building the Case for Hybrid Distributed Energy Developments Workshop – Day 2

April 5, 2023

Photo by Dennis Schroeder, NREL 55200

Fully Coupled Hybrid System Design

- **Objective:** Accelerate the nationwide understanding, development, and deployment of wind-based hybrids
- Developing a nationwide, end-to-end approach—from design to demonstration—of **fully coupled** wind-based hybrid plants
- **Utility to community scales**
- **Firm power** to minimize uncertainty in renewable energy through combination of storage, forecasting, and controls

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Can the Power Grid Handle a Wave of New Electric Vehicles?

The consensus is that utilities can generate enough electricity. The problem is going to be getting it to people's homes and businesses.

By Bart Ziegler Follow

Feb. 5, 2023 11:00 am ET

2/23/23, 2:47 PM Wind and Solar Energy Projects Risk Overwhelming America's Antiquated Electrical Grids - The New York Times

The New York Times https://www.nytimes.com/2023/02/23/climate/renewable-energy-us-electrical-grid.html

The U.S. Has Billions for Wind and Solar Projects. Good Luck Plugging Them In.

An explosion in proposed clean energy ventures has overwhelmed the system for connecting new power sources to homes and businesses.

By Brad Plumer

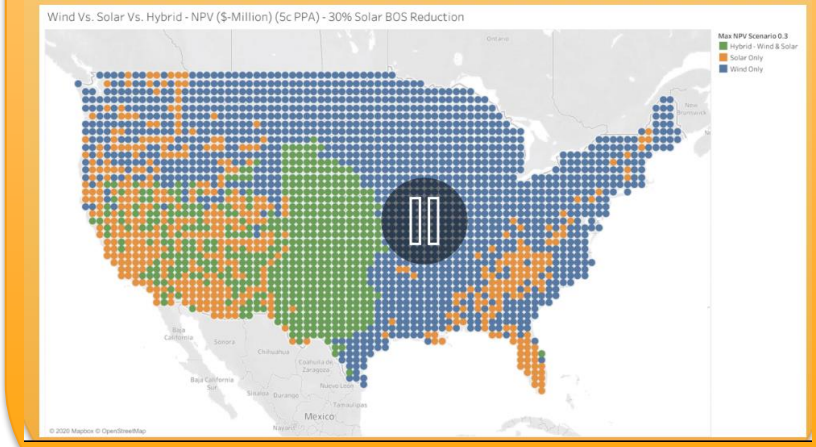
Feb. 23, 2023 Updated 12:37 p.m. ET 7 MIN READ

Hybrid Optimization and Performance Platform Capabilities

Analysis

Where to build co-located hybrid plants?

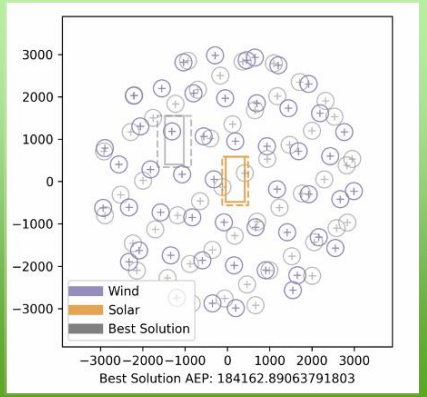
- Resources are complementary
- Overbuild (E.g., 200-megawatt [MW] plant at 100-MW interconnect)
- Include storage



Strong solar during day and strong wind at night

Design

Optimize hybrid plants down to the *component* levels

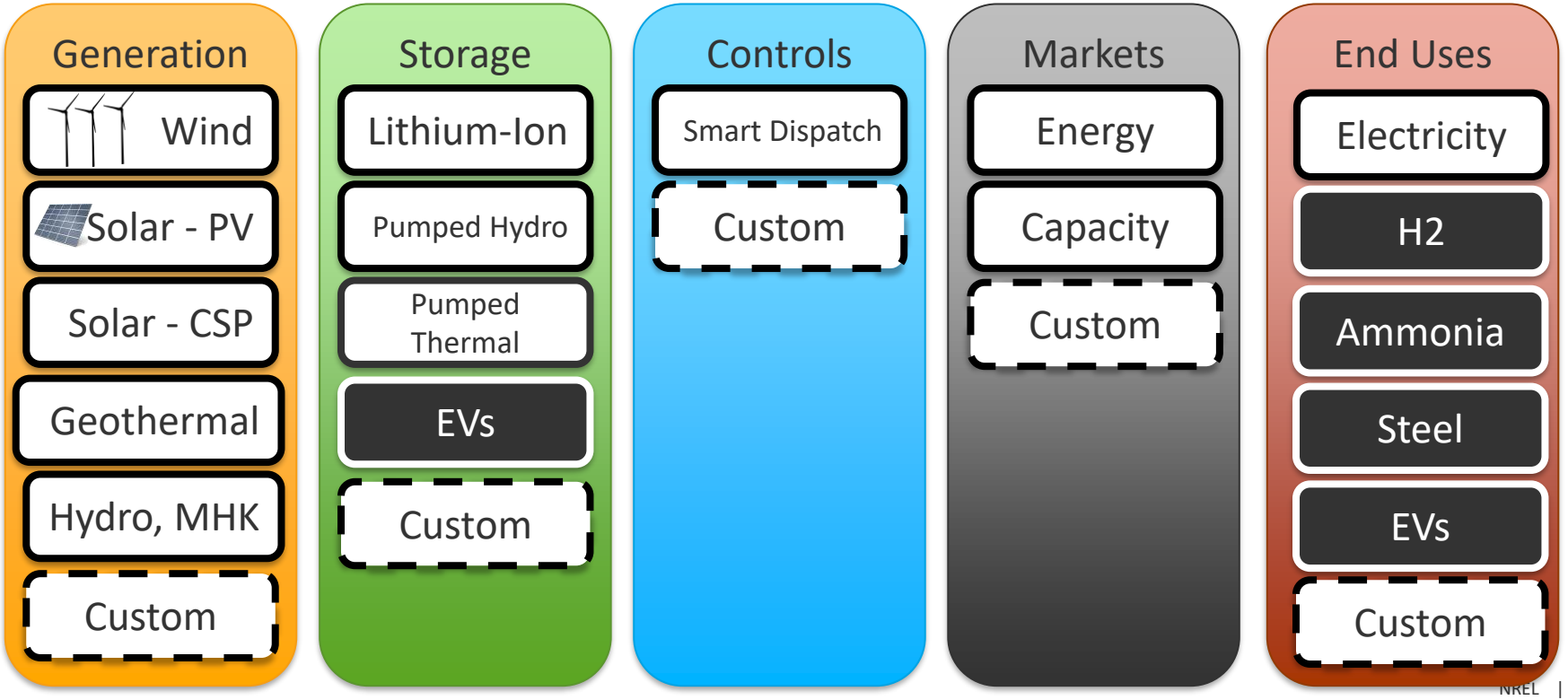


Control/Dispatch Algorithms

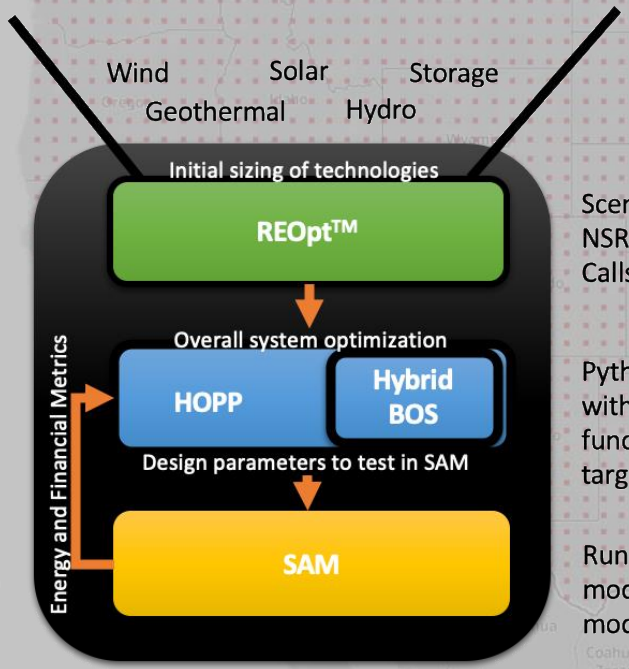
- **Wind-solar-storage** dispatch algorithms developed in Hybrid Optimization and Performance Platform (HOPP)
- Operation of plants down to the **1-minute timescale**
- Improve performance of hybrid power plants by > 5%

Hybrid Optimization and Performance Platform

Optimize co-located, utility-scale hybrid plants down to the component level for different markets



Hybrid Optimization and Performance Platform



Repeat until **convergence** on a feasible and economically viable solution

Scenario setup: interface with NSRDB, WindToolKit, URDB, Calls the REOpt API

Python-based optimization with customize objective function depending on the target markets

Run SAM performance models and financial models

Wind Design Variables

1. Number of turbines
2. (x,y) locations – layout
3. Hub height
4. Rotor diameter

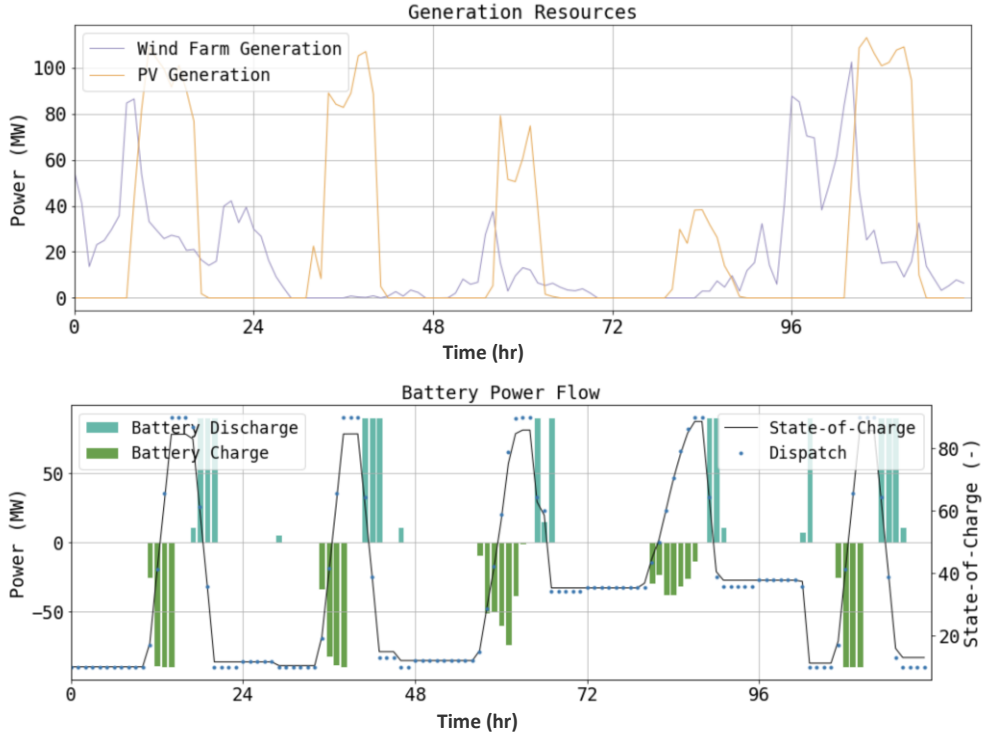
Solar Design Variables

1. Number of panels in a row
2. Number of rows
3. Tilt angle
4. Spacing between rows
5. *Future:* controls

Storage Design Variables

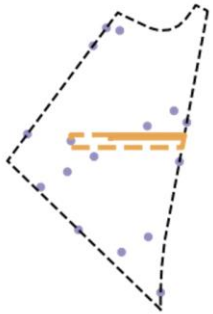
1. Charge/discharge rate
2. Operational timescale

Wind-Solar Hybrid Layout Example



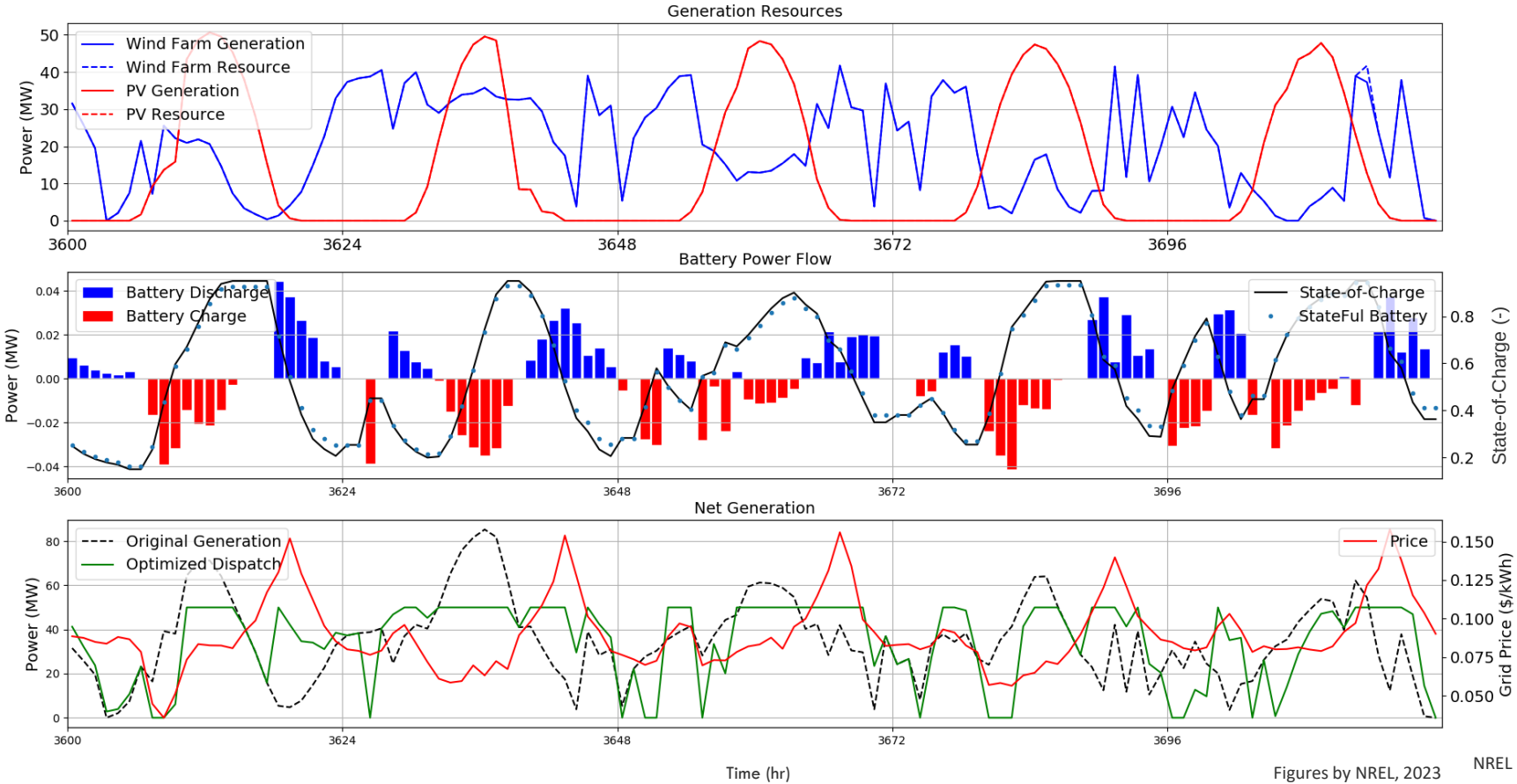
Best NPV $21.64M

96 MW Wind, 6 MW Solar, 0 MW Battery



Figures by NREL, 2023

Dispatch Optimization Results – With Forecasting



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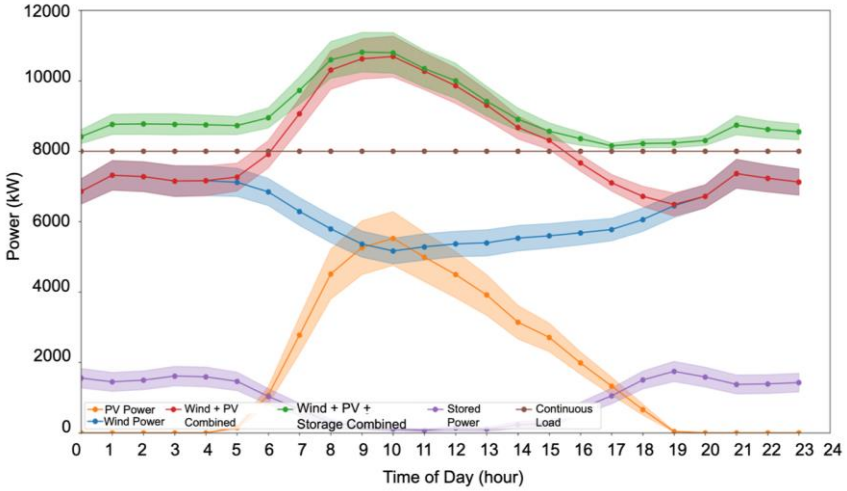
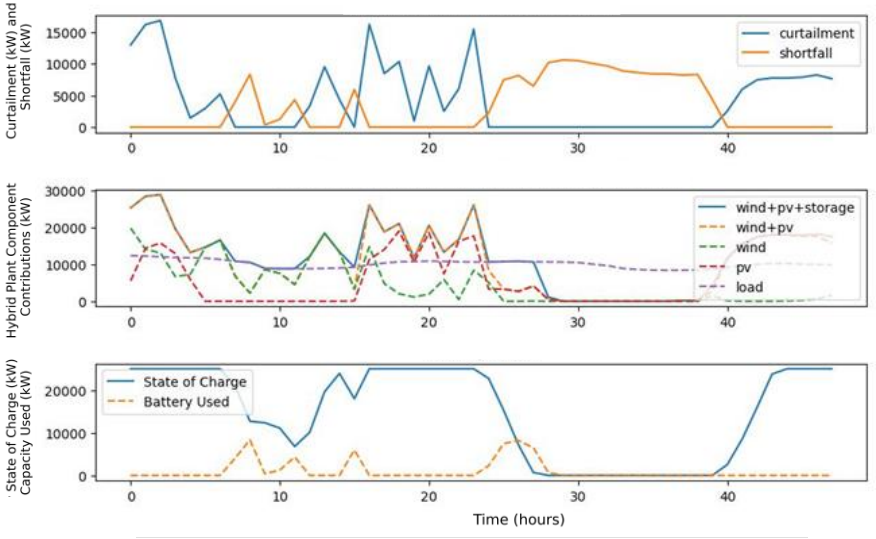
Community Hybrids



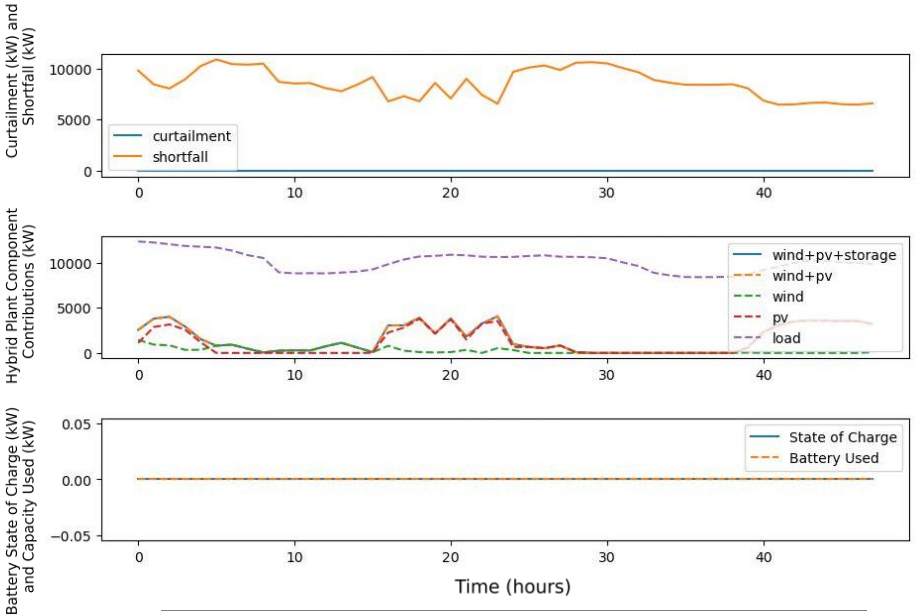
Example of a hybrid plant simulation in Tennessee



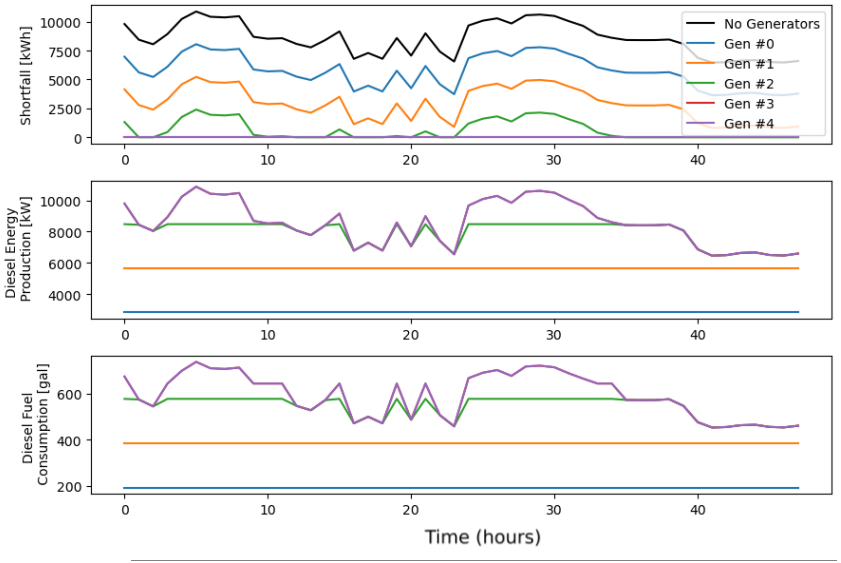
Example of a hybrid plant simulation in Iowa to meet specific load

Figures by Caitlyn Clark, 2023

Community Hybrids



Example of a wind-solar-battery hybrid plant simulation in Iowa



Example of a diesel generator simulation in Iowa as part of a hybrid plant

Figures by Caitlyn Clark, 2023

New Capabilities for Hydrogen

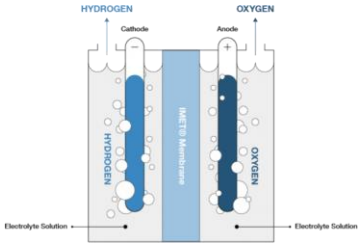
On vs. Off-Grid Systems

Demonstrate the cost trade-offs between on/off-grid with ultra-cheap energy

Impact: Can cost-effectively build in remote locations without transmission

Electrolyzer Simulation

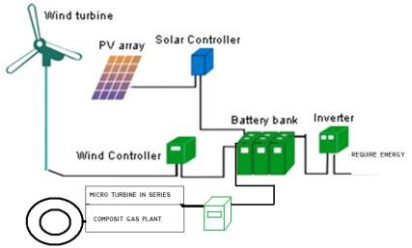
State-of-the-art electrolyzer models that include realistic operation, degradation, and cost modeling that accounts for scale



Impact: Realistically model how to achieve cost-competitive hydrogen (H_2)

Optimal Design for End Uses

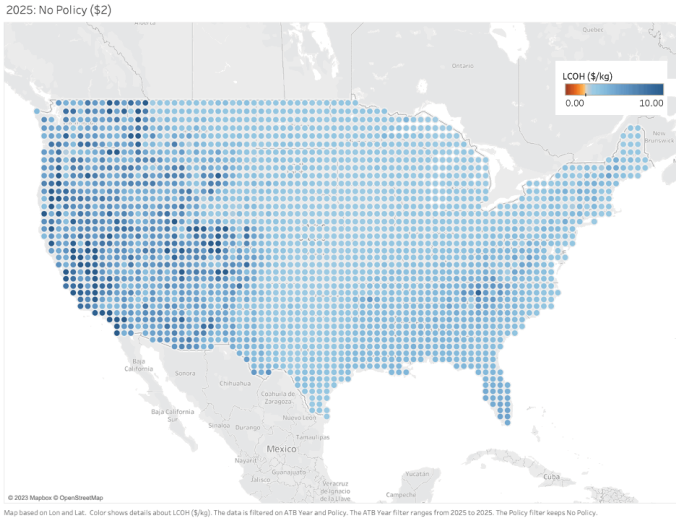
Optimal design inform the user how to design their power plant for different objectives and end uses

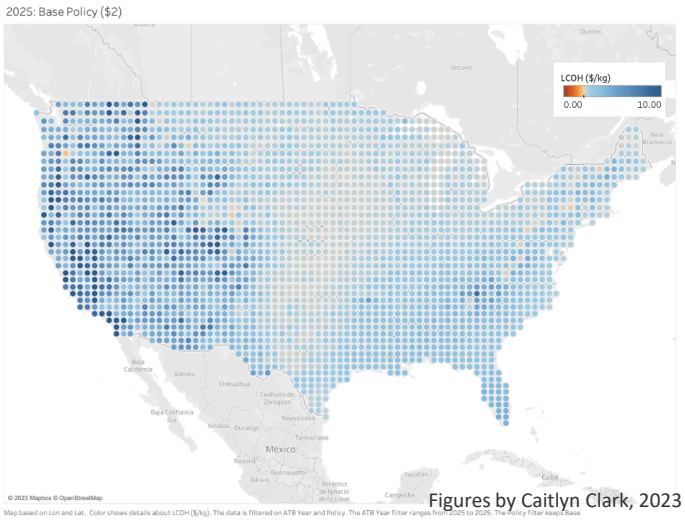


Impact: Different designs required for different objectives/markets/locations

Land-Based Wind to H_2

- Off-grid, onshore wind, solar, battery, hydrogen
- Fixed and optimized capacities
- Vary technology costs, financial assumptions, policy support (add a layer of stacking)





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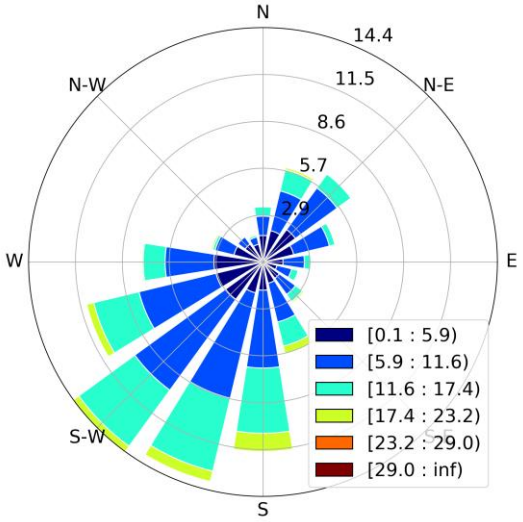
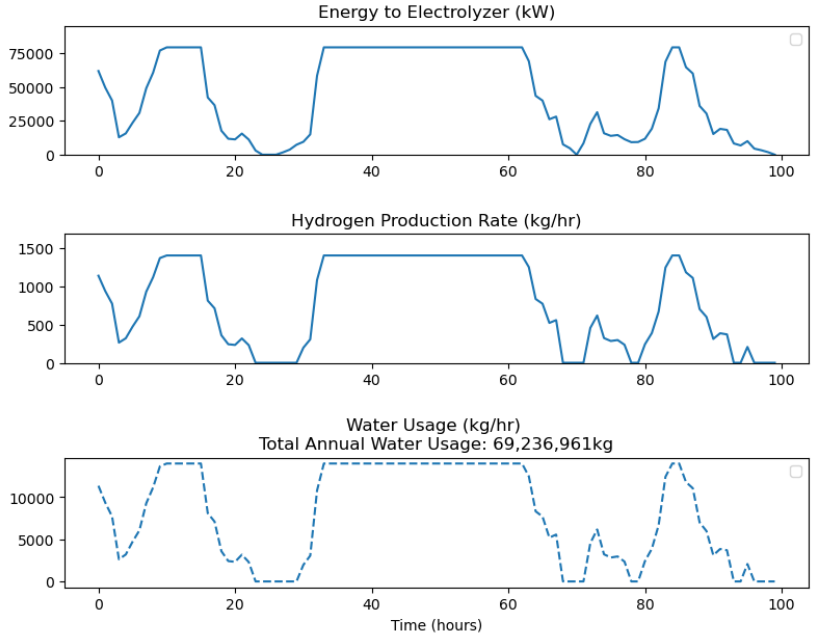
Land-Based Wind to H_2





Example of a wind electrolyzer system simulation in Texas

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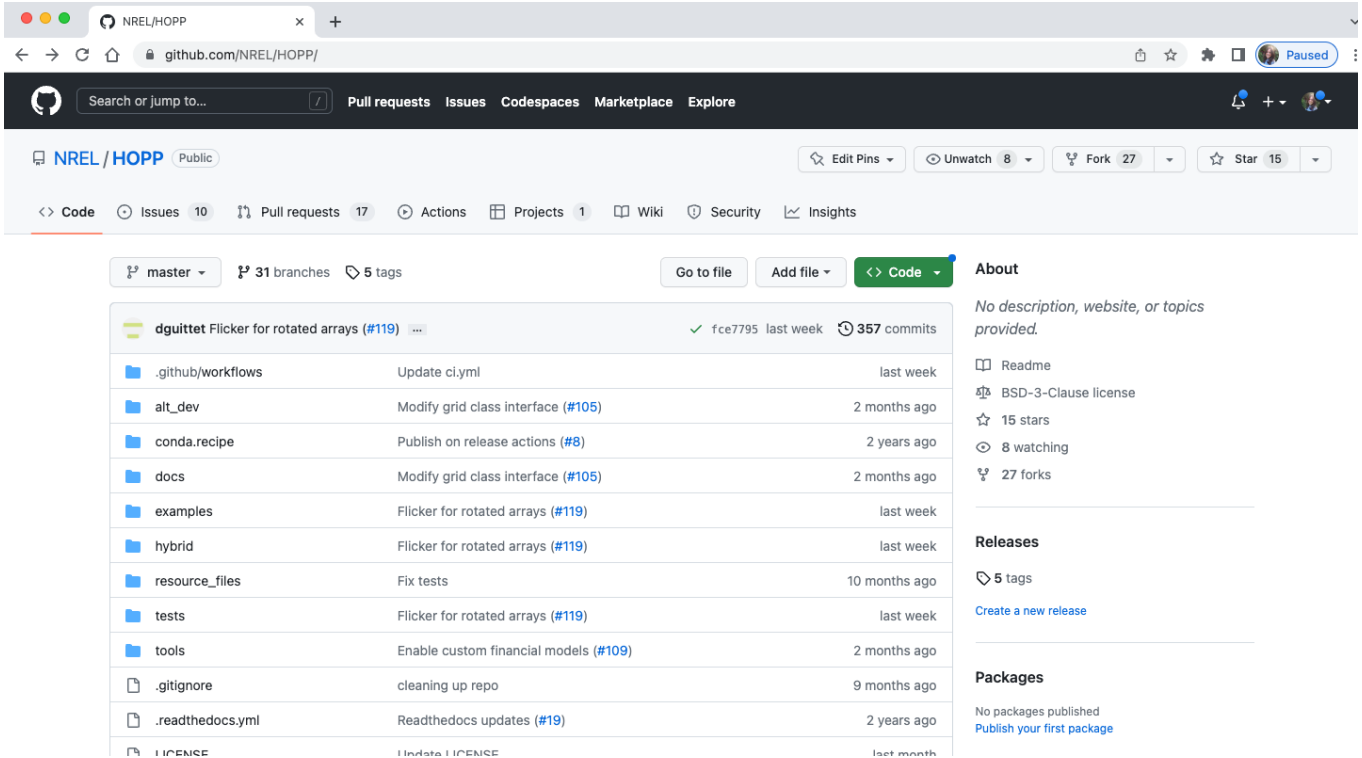
Let’s Take a Look…



Where to Next?

Current Work:

- Revenue models
- Community hydrogen
- Resilient-optimal dispatch
- V2G strategies/behaviors
- Design and control for reliability

Resources:

- On-Site for Rural Loads (megan.culler@inl.gov)
- Microgrids, Infrastructure Resilience, and Advanced Control Launchpad: https://www.nrel.gov/wind/miracl-report/
- Hybrid Optimization and Performance Platform: https://github.com/NREL/HOPP
- Turbine Model: https://github.com/NREL/turbine-models/
- Complementary work: https://www.nrel.gov/docs/fy22osti/80415.pdf
- Land-Based Wind to Hydrogen (in prep)
- Hybrid Power Plants for Energy Resilience: A Case Study (in prep)
- Hybrid Power Plants – An effective way for decreasing loss of load expectation (in prep)

Caitlyn.Clark@nrel.gov

Thank you

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